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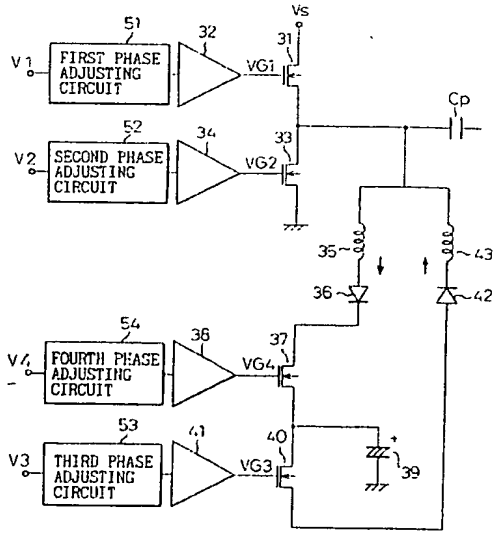
(54) Plasma display apparatus and manufacturing method

(57) A PDP apparatus equipped with a sustaining circuit that prevents the on/off timing shifts and consequent deterioration of sustaining pulses. Phase adjusting circuits (51-54), which adjust the timing of the changing edge of the sustaining pulses, are provided in a sustaining circuit, and the efficiency of a power recovery circuit is improved by optimizing the timing of the changing edge of the sustaining pulses. The circuit devices used in the sustaining circuits are classified according to delay times and sets of the circuit devices are selected so that the timing of the changing edge of the sustaining pulse falls within a predetermined allowance range, and the selected sets of the circuit devices are installed in the PDP. In this way, power consumption is reduced and malfunctions are prevented.

Fig.7



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Description

[0001] The present invention relates to a plasma display apparatus and a method of manufacturing the same. for example, the present invention relates to a plasma display apparatus equipped with a power recovery circuit in a sustaining circuit that reduces power consumption, a plasma display panel employing the ALIS (Alternate Lighting of Surfaces) system, in which plural first and second electrodes are arranged adjacently and display lines are formed between every pair of adjacent electrodes, and to control circuitry for a plasma display panel.

[0002] The plasma display panel (PDP) has good visibility because it generates its own light, is thin and can be made with a large and high-speed display, therefore, it is attracting interest as a replacement for the CRT display. Since the structure of a typical PDP has been disclosed in Japanese Unexamined Patent Publication (Kokai) No. 7-160219, Japanese Unexamined Patent Publication (Kokai) No. 9-160525, and Japanese Unexamined Patent Publication (Kokai) No. 9-325735, a detailed explanation is omitted here and, instead, only points relating directly to the present invention are explained.

[0003] FIG.1 is a block diagram showing the overall structure of a general PDP apparatus. In a PDP 10, n X electrodes 11 and Y electrodes 12 are arranged adjacently by turns, forming n pairs each of one X and one Y electrode 12, and light is emitted for display between the X electrode 11 and Y electrode 12 of each pair. Y electrodes and X electrodes are called display electrodes or sustaining electrodes. Address electrodes 13 which are normal to the display electrodes are provided, and display cells are formed at crossings of the address electrodes and X-Y electrode pairs.

[0004] The Y electrodes 12 are connected to a scan driver 14 (see Figure 2); this is equipped with switches 16, the number of which being equal to that of the Y electrodes and the switches are switched so that scan pulses from a scan signal generating circuit 15 are applied sequentially during the address period, and sustaining pulses from a Y sustaining circuit 19 are applied simultaneously during the sustaining discharge period. The X electrodes 11 are connected commonly to an X sustaining circuit 18, and the address electrodes 13 are connected to an address driver circuit 17. In an image signal processing circuit 21, image signals are converted so as suit the operation in the PDP apparatus, and are then supplied to the address driver circuit 17. A drive control circuit 20 generates and supplies signals that control each part of the PDP apparatus.

[0005] FIG.2 is a time chart showing drive signals of the PDP apparatus. In the PDP apparatus, a display frame is refreshed at predetermined intervals, and a display period is called a field. In order to realize a gray scale, a field is divided into a plurality of subfields and the subfields that emit light are selected for each display cell. Each subfield consists of the reset period during which all display cells are initialized, the address period during which all display cells are put into the status corresponding to the display image, and the sustaining discharge period during which each display cell emits light according to the set status. During the sustaining discharge period, sustaining pulses are applied to X electrodes and Y electrodes alternately and sustaining discharges are performed in the display cell specified to emit light during the address period, resulting in light emission for display.

[0006] In the PDP apparatus, it is necessary to apply a voltage of about 200 V at maximum between electrodes as a high frequency pulse during the sustaining discharge period, the width of a pulse is a few microseconds in a system in which the gray scale is realized by the representation of subfields. Since such a high voltage and a high frequency signal are required to drive a PDP, the power consumption of a general PDP apparatus is large and reduction in power consumption is demanded. United States Patent No. 4,070,663 discloses a control method to suppress the power consumption of the capacitive display unit such as an EL (Electro-Luminescence) apparatus, in which an inductor device is provided to form a resonant circuit with the capacitor of the display unit.

[0007] In addition, the sustaining discharge driver and the address driver for the PDP panel equipped with a power recovery circuit consisting of inductor devices have been disclosed in United States Patent No. 4,866,349 and United States Patent No. 5,081,400. Moreover, in Japanese Unexamined Patent Publication (Kokai) No. 7-160219, the construction of a three-electrode type display unit equipped with two inductors coupled to the Y electrode, one of which forms a recovery circuit to recover the applied power while the Y electrode is switched from a high voltage state to a low voltage state, and the other inductor forms an application path to apply the accumulated power while the Y electrode is switched from a low voltage state to a high voltage state.

[0008] FIG.3 is a schematic showing an example of a typical construction of a sustaining circuit equipped with a power recovery circuit, in which a circuit to recover power (i.e. electrical charge) and a circuit to apply the accumulated power is separated. Circuits to-generate signals V1 to V4 are also provided, but they are omitted here. Reference code Cp refers to a drive capacitance of a display cell, formed by the X electrode and Y electrode of a PDP. Though a sustaining circuit of one of the electrodes is shown here, the other electrode is also connected to a similar sustaining circuit. In the circuit in FIG.3, the part consisting of output devices (transistors) 31 and 33, and drive circuits 32 and 34 is a sustaining circuit without a power recovery circuit, and the part consisting of output devices (transistors) 37 and 40, drive circuits 38 and 41, inductance devices 35 and 43, capacitor 39, and diodes 36 and 42, is a power recovery

circuit. The signals V1 and V2 are supplied to the drive circuits 32 and 34, respectively, and the signals VG1 and VG2 output therefrom are supplied to the gates of the output devices (transistors) 31 and 33. When the signal V1 is "High (H)", the output device 31 turns on and an H level signal is applied to the electrode. At this time, the signal V2 is "Low (L)", and the output device 33 is off. Immediately after the signal V1 turns to L and the output device 31 turns off, the signal V2 turns to H and the output device 33 turns on, and the ground level is applied to the electrode.

[0009] In the sustaining circuit with the power recovery circuit, when sustaining pulses are applied, signal V2 turns to L and signal V1 turns to H. This switches off the output device (33). Then the signal V3 turns to H, turning output device (40) on and a resonant circuit is formed by the capacitor 39, diode 42, inductor 43, and capacitor Cp, and the charge stored in the capacitor 39 is supplied to the electrode, causing the potential of the electrode to rise. Just before the increase of the potential is completed, the signal V3 turns to L and the output device 40 turns off, then the signal V1 turns to H and the output device 31 turns off, thus the potential of the electrode is fixed to Vs. When the application of sustaining pulses is terminated, the signal V1 turns to L first and after the output device 31 turns off, the signal V4 turns to H, the output device 37 turns on, and a resonant circuit is formed by the capacitor 39, diode 36, inductor 35, and capacitor Cp, and the charge stored in the capacitor Cp is supplied to the capacitor 39, thus the voltage of the capacitor 39 is raised. Therefore, the charge stored in the capacitor Cp is transferred to the capacitor 39 by the sustaining pulses applied to the electrode. Just before the reduction in potential of the electrode is completed, the signal V4 turns to L, the output device 37 turns off, then the signal V2 turns to H, the output device 33 turns on, and the potential of the electrode is fixed at ground level. During the sustaining discharge period, the above-mentioned operation is repeated a number of times equal to that of the sustaining pulses. In the structure mentioned above, the power consumption caused by the sustaining discharge can be suppressed.

[0010] On the other hand, a higher precision of the display is required for the PDP apparatus, and a system in which light is emitted for display between every adjacent display electrode has been disclosed in Japanese Patent No. 2801893. This system is called the ALIS system and is called the same here. Since the detail of the structure of the ALIS system has been disclosed in Japanese Patent No. 2801893, only the points relating to the present invention are explained here.

[0011] FIG.4 is a general block diagram of a PDP employing the ALIS system. As shown schematically, in the PDP employing the ALIS system, n Y electrodes (second electrodes) 12 - O and 12 - E and n+1 X electrodes (first electrodes) 11 - O and 11 - E are arranged adjacently in turn and light is emitted between every adjacent display electrode (Y electrode and X electrode). Therefore, 2n+1 display electrodes form 2n display lines. This means that the precision can be doubled with the same number of the display electrodes as that in FIG.1, in the ALIS system. The ALIS system is also characterized by a high luminance because the discharge space can be used efficiently without any waste and a high opening ratio can be obtained to give a small loss of light due to electrodes or the like. Light is emitted between every adjacent display electrode for display in the ALIS system, but it is impossible to cause all discharges to occur at the same time. Therefore, so-called interlaced scanning, in which odd-numbered lines and even-numbered lines are used in a time-shared manner for display, is employed. In the odd field, odd-numbered display lines are used for display, and even-numbered display lines are used for display in the even field, and the display combining the odd field and the even field is obtained as a total display.

[0012] Y electrodes are connected to the scan driver 14. The scan driver 14 is equipped with switches 16, and the switches are switched so that scan pulses are applied sequentially during the address period, and in the sustaining discharge period, the odd-numbered Y electrode 12 - O is connected to the first Y sustaining circuit 19 - O and the even-numbered Y electrode 12 - E is connected to the second Y sustaining circuit 19 - E. The odd-numbered X electrode 11 - O is connected to the first X sustaining circuit 18 - O, and the even-numbered X electrode 11 - E is connected to the second X sustaining circuit 18 - E. The address electrodes 13 are connected to the address driver circuit 17. The image signal processing circuit 21 and the drive control circuit 20 work in the similar manner as explained in FIG.1.

[0013] FIGs.5A and 5B show drive signals during the sustaining discharge period in the ALIS system. FIG.5A shows waveforms in the odd field and FIG.5B shows those in the even field. In the odd field, a voltage Vs is applied to the electrodes Y1 and X2, X1 and Y2 are grounded, and discharge is caused to occur between X1 and Y1, and X2 and Y2, that is, at the odd-numbered display lines. At this time, the voltage difference between Y1 and X2, which form the even-numbered display line, is zero and no discharge is caused to occur. Similarly, in the even field, a voltage Vs is applied to the electrodes X1 and Y2, Y1 and X2 are grounded, and discharge is caused to occur between Y1 and X2, and Y2 and X1, that is, at the even-numbered display lines. The explanation about the drive signals during the reset period and the address period is omitted.

[0014] In the power recovery circuit shown in FIG.3, it is essential to recover and apply power (electrical charge) efficiently, and achievement of a high rate of power recovery is expected. The achievement of a high rate of power recovery is influenced by the on/off timing of the output devices 31, 33, 37, and 40. To show the effect of this timing, FIG.6A shows a case where the clamp timing is advanced and FIG.6B shows a case where the clamp timing is delayed.

[0015] As explained above, when sustaining pulses are applied, the output device 40 turns on and the charge accumulated in the capacitor 39 is supplied to the electrode, and just before the increase of the potential of the electrode is completed, the signal V3 turns to L, the output device 40 turns off, and at the same time, the signal V1 turns to H, the output device 31 turns on, thus the potential of the electrode is clamped to Vs. As shown in FIG.6A, however, if the output device 31 turns on before the output device 40 turns off, the electrode is connected to the power source of voltage Vs halfway through the potential of the electrode being raised by the charge accumulated in the capacitor 39 because of the turn-on of the output device 31. Therefore, the power for the rest of the process is supplied from the power source and a part of the charge stored on the capacitor 39 is wasted and not utilized. Similarly, when the application of sustaining pulses is terminated, if the output device 37 turns on to cause the output device 33 to turn on while the power is being recovered into the capacitor 39, the electrode is clamped to the ground level before the power is recovered sufficiently, therefore the recovery of power is not completed.

[0016] Moreover, as shown in FIG.6B, when the sustaining pulses are applied, if the output device 31 turns on after the output device 40 turns off, the increase of the potential of the electrode by the charge stored in the capacitor 39 is terminated, and since the output device 31 turns on after the potential of the electrode begins to drop, and the electrode is clamped to the power source of voltage Vs, it is required to raise the dropped potential, resulting in excessive power consumption. Similarly, when the application of the sustaining pulses is terminated, if the output device 33 turns on after the output device 37 turns off, the electrode is clamped to the ground level after the potential, which has been once lowered, begins to rise again, therefore it is required to reduce the increased potential, resulting in excessive power consumption.

[0017] As explained above, if the on/off timing of the output devices 31, 33, 37, and 40 in the sustaining circuit is shifted, a problem occurs that the power (charge) recovery rate is reduced and the power consumption increases. The on/off timing of output devices 31, 33, 37, and 40 is the timing of the change of the signals V1, V2, V3, and V4 plus delay times of the drive circuits 32, 34, 38, and 41, and further plus delay times of the output devices 31, 33, 37, and 40. Though the timing of change of the signals V1, V2, V3, and V4 can be determined with a comparatively high precision, the delay times of the drive circuits 32, 34, 38, and 41, and those of the output devices 31, 33, 37, and 40 are dispersed depending on variations in characteristics of the devices used. Therefore, the power recovery rate for each PDP apparatus varies between units, becoming lower than that in an ideal case, and a problem occurs that the power consumption increases.

[0018] As explained above, if the variations in delay times of the circuit devices cause the shapes and timings of the sustaining pulses to change, the possibility of a malfunction is increased. In general, the difference ΔVs, which is called the operation margin, of the maximum value Vs (max) and the minimum value Vs (min) in the operational range of the operating voltage Vs is reduced when the delay times of the circuit devices are dispersed and the shapes and timing of the sustaining pulses are altered. This means a deterioration in the operation stability of the apparatus.

[0019] In the ALIS system, discharge for light emission does not take place between adjacent electrodes to which the same voltage is applied, respectively. If, however, the timing of application is shifted, a problem may arise when discharge for light emission takes place temporarily at the display lines not for display and wall-charge accumulated during the address period decreases, resulting in an abnormal display. For example, in FIG.5A, if sustaining pulses are applied to Y1 electrodes and to X2 electrodes after a delay, a situation may occur, temporarily, in which a Y1 electrode is H and at the same time that an X2 electrode is L, and erroneous discharge for light emission may take place between a Y1 electrode and an X2 electrode. Though such erroneous discharge for light emission ceases when sustaining pulses are applied to X2 electrode, the wall-charges of Y1 electrode and X2 electrode decrease and the normal light emission for display may be reduced.

[0020] As explained above, there has been a problem that power consumption is increased and a malfunction occurs when the time delays in each circuit device in the sustaining circuit are dispersed and therefore, the on/off timing and the shapes of the sustaining pulses are shifted or changed.

[0021] The present invention has been developed in view of these problems and an embodiment of the present invention aims to realize a sustaining circuit in which the on/off timing and the shapes of the sustaining pulses are not shifted or changed, and a PDP apparatus with low power consumption and free from malfunctions is provided.

[0022] Accordingly, the PDP apparatus of the present invention is provided with a sustaining circuit having phase adjusting circuits that adjust the timing of the changing edge of the sustaining pulse. By adjusting the phase adjusting circuits and optimizing the state of the timing of the changing edge of the sustaining pulse, a power recovery circuit can work efficiently and the power consumption will be reduced. In addition, since the on/off timingsof the sustaining pulses applied from each sustaining circuit are optimized to each other, malfunctions or erroneous discharge can be avoided.

[0023] It is particularly effective if the present invention is employed in a PDP apparatus equipped with the sustaining circuit having a power recovery circuit, or one employing an ALIS system.

[0024] In the case of the sustaining circuit equipped with a power recovery circuit, as shown in FIG.3, it is

required for the phase adjusting circuit to be able to adjust the time differences from turn-on of the third output device to that of the first output device, and from turn-on of the fourth output device to that of the second output device.

[0025] In the case of the ALIS system as shown in FIG.4, it is-required to be able to adjust the timing of the sustaining pulses applied between adjacent electrodes to prevent erroneous discharge. For example, the difference of the rise timing or the fall timing between the sustaining pulse output by the first X sustaining circuit and that of the first or the second Y sustaining circuit, and the difference of the rise timing or the fall timing between the sustaining pulse output by the second X sustaining circuit and that of the first or the second Y sustaining circuit are adjusted to be lower than a predetermined value, for example, within ±30 ns.

[0026] When the adjustment is performed using the phase adjusting circuit mounted to the PDP, the optimized state can be obtained according to the actual capacity of the electrode of the PDP.

[0027] In addition, it will also be preferable to mount the set of the selected circuit devices after selecting the combination of the circuit devices, which have been classified in advance according to the delay times and are to be used in the sustaining circuit, so that the timing of the changing edge of the sustaining pulse falls within a predetermined range.

[0028] The present invention also embraces control circuitry for a PDP.

[0029] Reference will now be made, by way of example, to the accompanying drawings in which:

FIG.1 is a block diagram showing the general structure of a PDP apparatus;
FIG.2 is a time chart showing the drive signals of the PDP apparatus;
FIG.3 is a schematic showing an example of the structure of the sustaining circuit equipped with the power recovery circuit;
FIG.4 is a block diagram showing the general structure of a PDP apparatus employing the ALIS system;
FIGs.5A and 5B show time charts showing the drive signals during the sustaining discharge period in the ALIS system;
FIGS.6A and 6B show time charts showing the influence of the shift of the timing in the power recovery circuit;
FIG.7 is a schematic showing the structure of the sustaining circuit in an embodiment of the present invention;
FIG.8 is a time chart showing the operation of the sustaining circuit in the embodiment;
FIG.9 is a schematic showing the effect of decreasing the power consumption of the present invention;
FIG.10 is a schematic showing the effect of increasing the operation margin in the ALIS system of the present invention;
FIGs.11A through 11P show schematics showing examples of phase adjusting circuits in the embodiments;
FIG.12 is a flow chart showing a process of setting the phase adjusting circuit;
FIG.13 is a flow chart showing a process of setting the phase adjusting circuit with the variations in characteristics of the PDP taken into account;
FIG.14 is a flow chart showing a manufacturing method of combining the circuit devices, which have been classified in advance according to the delay times, in the sustaining circuit;
FIG.15 is a flow chart showing the manufacturing method when only the increase of the power recovery rate is aimed; and
FIG.16 is a flow chart of the manufacturing method when the variations in characteristics of the PDP are taken into account.

[0030] An embodiment in which the ALIS system of the present invention is applied to a PDP apparatus is described below. The PDP apparatus of the present invention has the general structure as shown in FIG.4, and the first and the second X sustaining circuits 18 - O and 18 - E, and the first and the second Y sustaining circuits 19 - O and 19 - E have the structures as shown in FIG. 7. Similarly, as in FIG.3, the circuits that generate the signals V1 through V4 are not shown.

[0031] The sustaining circuit in the embodiment is different from the structure as shown in FIG.3 in that the first phase adjusting circuit 51 to the fourth phase adjusting circuit 54 are provided in the former stage of each drive circuit 32, 34, 38, and 41. Even though the delay times of the output devices 31, 33, 37, and 40, and those of the drive circuits 32, 34, 38, and 41 are dispersed, it is still possible to achieve the optimized state of the on/off timing of the output devices 31, 33, 37, and 40 as shown in FIG.8 by adjusting the delay in the first phase adjusting circuit 51 through the fourth phase adjusting circuit 54.

[0032] FIG.9 is a schematic showing the effect of decreasing the power consumption in the present invention. As shown schematically, the power consumption increases in proportion to the number of sustaining pulses in the sustaining circuit. The constant of proportionality of the increase is largest when the power recovery circuit is not employed. It can be decreased considerably by employing the power recovery circuit as shown in FIG.3, and it can be decreased further along with power consumption by employing the present invention.

[0033] FIG.10 is a schematic showing the improved effect of the operation margin of the present invention. The difference Δ Vs of the maximum value Vs (max) and the minimum value Vs (min) of the aforementioned operating voltage is used as the operation margin. As shown schematically, as the discharge current increases the operation margin decreases, but the decrease of

the operation margin is smaller compared to the structure in FIG.3 when the present invention is applied.

[0034] The circuit structure of the phase adjusting circuit is now described. The phase adjusting circuit is used to adjust the delay time of a signal and various delay circuits are widely known and available to use. FIGS. 11A through 11P are schematics showing the phase adjusting circuits. FIG.11A shows a delay circuit consisting of a variable resistor VR and a capacitor C, FIG.11B shows that of a variable inductor VL and capacitor C, FIG.11C shows that of a variable resistor VR1 for coarse adjustment, a variable resistor VR2 for fine adjustment, and a capacitor C, FIG.11D shows that of a variable inductor VL1 for coarse adjustment, a variable inductor VL2 for fine adjustment, and a capacitor C, FIG.11E shows that of a resistor TR whose resistance value can be adjusted by trimming and a capacitor C, FIG.11F shows that of an inductor TL whose inductance value can be adjusted by trimming and a capacitor, FIG.11G shows that of a trimming resistor TR1 for coarse adjustment, a trimming resistor TR2 for fine adjustment, and a capacitor C, FIG.11H shows that of a trimming inductor VL1 for coarse adjustment, a trimming inductor VL2 for fine adjustment, and a capacitor C, FIGs.11I and 11J show circuits that have additional buffer circuits B1 at the inputs and additional buffer circuits B2 at outputs of the circuits, respectively, in FIGs.11G and 11H, FIG.11K shows a circuit consisting of a register array RA, a switch array SA, and a capacitor C, in which RA and SA collaborate in generating a selected resistance value, FIG. 11L shows that of an inductor array LA, a switch array SA, and a capacitor C, in which LA and SA collaborate in generating a selected inductance value, FIG.11M shows a circuit equipped with an electronic variable resistor EVR, wh_{ose} resistance value can be set from the outside by the phase control signal, and a capacitor C, FIG.11N shows a circuit equipped with a delay line DL, which can select the delay using the phase control signal, FIG.11O shows a circuit, in which a phase shift circuit PS is provided before a drive circuit D, the actual output Vout of an output device T is detected in an output voltage detection circuit OD, the phase difference is determined from the input signal Vin and the detected result of the output voltage detection circuit OD in a phase difference detecting circuit, and the delay of the phase shift circuit PS is adjusted accordingly, and FIG.11P shows a circuit that differs from FIG.11O only in that a drive voltage detecting circuit DD, which detects the output of the drive circuit D, is employed instead of the output voltage detection circuit OD, and the delay time of the output device T cannot be adjusted in this circuit. Though not shown here, a variable capacitor C may also be used.

[0035] Next, the process of adjusting and setting each phase adjusting circuit of each sustaining circuit in the embodiments is described.

[0036] FIG.12 is a flow chart showing the process of setting the phase adjusting circuit. A delay time of an output device is measured in step 101, a delay time of a drive circuit, which is used with the above-mentioned output device, is measured in step 102, a delay time of a phase adjusting circuit to be used together is calculated by subtracting the above-mentioned two delay times from a predetermined delay time in step 103, and the delay time of the phase adjusting circuit to be used together is set based on the calculated delay time in step 104. Such a process is applied to all sets. As a result, each output device turns on or off with a predetermined timing. Therefore, the power consumption can be reduced to the minimum and erroneous charge and malfunctions can be avoided.

[0037] The process shown in FIG.12 compensates for variation in delay times of the output devices and the drive circuits, and is performed before the sustaining circuit is put in the PDP apparatus. It is preferable, however, to optimize the timing of the sustaining pulses according to the PDP apparatus because there may be a variation in capacitances between electrodes of the PDP apparatus due to the manufacturing process, thus changing the time constant of the oscillation circuit in the power recovery circuit. FIG.13 is a flow chart showing a process of setting the delayed time of the phase adjusting circuit to the optimum value, with the variation in the PDP apparatuses driven by the sustaining circuit taken into account.

[0038] In step 111, the sustaining circuit is assembled while being set to the device including the PDP apparatus. In this step, just an operating status is required, not a complete assembly. In step 112, a circuit for adjusting is selected among from the first X sustaining circuit 18 - O, the second X sustaining circuit 18 - E, the first Y sustaining circuit 19 - O, and the second X sustaining circuit 18 - E. In step 113, a set for adjusting is selected, to be more specific, a phase adjusting circuit for adjusting is selected from the first to the fourth phase adjusting circuits 51 through 54. In step 114, the waveforms relating to the selected sets of the PDP apparatus are measured, in step 115, it is established whether or not the results are within the allowed ranges with respect to the specified reference signal, and if the results are not within the allowed ranges, the phase adjusting circuit is adjusted in step 116, and steps 114 through 116 are repeated until the results are within the allowed ranges.

[0039] In step 117, whether the above-mentioned process is finished for all sets is determined, and if not, the set for adjusting is changed in step 118 and the procedure returns to step 114. As explained above, the adjustment of the four phase adjusting circuits of the circuit for adjusting is completed, and the sustaining pulses output from the circuit turn on and off with a predetermined timing. In addition, in step 119, whether the above-mentioned process is completed for all circuits is determined, and if not, the circuit for adjusting is changed in step 120 and the procedure returns to step 114. Finally the adjustment of all the circuits is completed.

[0040] Though the phase adjusting circuits are provided in the embodiment described above, the timing of the sustaining pulse can be optimized by measuring the delay times of circuit devices to be used in the sustaining circuit, selecting a set in which the sum of delay times are within allowed ranges or, to be more specific, a set in which the sum of the delay times of the output devices and the drive circuit are within allowed ranges with respect to a predetermined value, and installing that set in the PDP apparatus. FIG.14 is a flow chart showing the manufacturing process mentioned above.

[0041] In step 131, a delay time of an output device is measured, and the devices are classified according to the delay times in step 132. In parallel with this process, a delay time of a drive circuit is measured in step 133 and the circuits are classified according to the delay times in step 134. With the above-mentioned process steps, the output devices and the drive circuits are classified according to the delay times.

[0042] In step 135, sets are made so that the sum of the delay times for each set is equal. For example, a PDP apparatus employing the ALIS system has four sustaining circuits, and each sustaining circuit has four sets of the output device and the drive circuit. That is, it is necessary to select 16 sets with the same sum of delay times because the PDP apparatus has 16 sets of the output device and the drive circuit. The sets of the output device and the drive circuits are set (installed) in step 136.

[0043] In the process mentioned above, though the 16 sets are selected for the sustaining circuit of a PDP apparatus so that the sum of delay times is equal for each of the sets, it is only required for the on/off timing of the output devices 31 and 34, and that of the output devices 33 and 37 to be in the specified relation for each sustaining circuit in order to improve the power recovery rate. FIG.15 is a flow chart showing the manufacturing process in this case.

[0044] After steps 131 through 134 as shown in FIG. 14, two sets of the output device and the drive circuit with the same sum of delay times are selected and used as the first output device 31 and drive circuit 32, and the third output device 40 and drive circuit 53 in step 141. Similarly, two sets of the output device and the drive circuit with the same sum of delay times are selected and used as the second output device 33 and drive circuit 34, and the fourth output device 37 and drive circuit 54 in step 142.

[0045] In order to prevent erroneous discharge in the ALIS system, there should be no difference in on/off timing when the sustaining pulse is applied between two adjacent electrodes. That is, there should be no difference in timing between the sustaining pulses put out of the first X sustaining circuit (applied to the odd-numbered X electrodes)and those put out of the first and the second Y sustaining circuits (applied to the odd-numbered and even-numbered Y electrodes). Also, there should be no difference in timing between the sustaining pulses put out of the second X sustaining circuit (applied to the even-numbered X electrodes), and those put out of the first and the second Y sustaining circuits (applied to the odd-numbered and the even-numbered Y electrodes). This eventually means that there is no difference in timing between every sustaining pulse. According to the results of the investigation of the timing difference with which no erroneous discharge is caused in the PDP apparatus employing the ALIS system, the occurrence rate of erroneous discharge is small when the difference between the sustaining pulses applied to the adjacent electrodes is within ±30 ns.

[0046] Even when the sets are selected after the delay time is measured, it is advisable to take the variation in capacitance into account. FIG.16 is a flow chart showing 'the manufacturing process in this case.

[0047] In step 151, the capacitance of the PDP, which the sustaining circuit drives, is measured, and the best delay time of the sustaining circuit to be set thereto is calculated. In step 152, a set of the classified output device and drive circuit is selected so that the delay time is optimized and is set in step 153.

[0048] Though an embodiment of the present invention was described above, if there are some other circuit devices that cause a delay in the sustaining pulse, it will be understood that their delay time should be taken into account.

[0049] As explained above, by means of the present invention, the on/off timing of the sustaining pulse that is influenced by the variation in delay time of the drive circuit in the sustaining circuit and that of the output devices, and the on/off timing of the output devices of the power recovery circuit can be optimized, therefore, the variation in power recovery rate in each PDP apparatus can be reduced, the power consumption on average can be also reduced, and the variation in operation margin can be improved, and moreover, the possibility of occurrence of erroneous discharge can be reduced in an ALIS-system PDP.

Claims

1. A plasma display apparatus comprising a plasma display panel equipped with first electrodes and second electrodes arranged adjacently in turn parallel to one another, and electrodes normal to the first and second electrodes,

   an X sustaining circuit that supplies sustaining pulses to the first electrodes, and a Y sustaining circuit that supplies sustaining pulses to the second electrodes, wherein the X sustaining circuit and the _ Y sustaining circuit are equipped with phase adjusting circuits that adjust the timing of changing edgesof the sustaining pulses.

2. A plasma display apparatus, as set forth in claim 1, wherein the X sustaining circuit and the Y sustaining

circuit include power recovery circuits each of which has a resonant circuit formed with a display capacitor of the plasma display panel, which recovers energy when the application of a sustaining pulse is released and uses the recovered energy for the next application of a sustaining pulse.

3. A plasma display apparatus, as set forth in claim 2, wherein the X sustaining circuit and the Y sustaining circuit comprise first and .second output devices connected between a path through which the sustaining pulses are supplied and a high voltage power source line, and between the path and a low voltage power source line, respectively, a third output device that switches the connection state of the path and the power recovery circuit to the state in which power is supplied from the power recovery circuit to the path, a fourth output device that switches the connection state of the path and the power recovery circuit to the state in which power is recovered from the path to the power recovery circuit, and first to fourth drive circuits that drive the first to fourth output devices; wherein the phase adjusting circuit can adjust the time difference between the turning on of the third output device and that of the first output device, and the time difference between the turning on of the fourth output device and that of the second output device.

4. A plasma display apparatus, as set forth in claim 3, wherein the phase adjusting circuit comprises first to fourth phase adjusting circuits provided at an input stage of the first to fourth drive circuits, respectively.

5. A plasma display apparatus, as set forth in claim 1, wherein the plasma display panel forms a first display line between one side of the second electrode and the adjacent first electrode, the second display line between the other side of the second electrode and the adjacent first electrode, and forms a display field of a frame by a plurality of subfields, and provides a gray scale by combining said subfields selectively for display; the X sustaining circuit is equipped with a first X sustaining circuit that supplies the sustaining pulsesto an odd-numbered electrode of the first electrodes, and a second X sustaining circuit that supplies the sustaining pulsesto an even-numbered electrode of the first electrodes; and the Y sustaining circuit is equipped with a first Y sustaining circuit that supplies the sustaining pulse to an odd-numbered electrode of the second electrodes, and a second Y sustaining circuit that supplies the sustaining pulsesto an even-numbered electrode of the second electrodes.

6. A plasma display apparatus, as set forth in claim 5, wherein the first and second X sustaining circuits and the first and second Y sustaining circuits are equipped with the phase adjusting circuits, respectively; and the difference in rising or falling timing between the sustaining pulse output by the first X sustaining circuit and that output by the first or second Y sustaining circuit, and the difference in rising or falling timing between the sustaining pulse output by the second X sustaining circuit and that output by the first or second Y sustaining circuit are adjusted so that the differences of the timings are within a predetermined range.

7. A plasma display apparatus, as set forth in claim 6, wherein the predetermined range is ±30 ns.

8. A plasma display apparatus, as set forth in any preceding claim, wherein the phase adjusting circuit is set by observing the waveform when the sustaining pulse is applied to the first or second electrode of the plasma display panel.

9. A manufacturing method of a plasma display apparatus comprising a plasma display panel having first electrodes and second electrodes arranged parallely and adjacently in turn and address electrodes at right angles to the first and second electrodes, an X sustaining circuit that supplies a sustaining pulse to the first electrodes, and a Y sustaining circuit that supplies a sustaining pulse to the second electrodes, wherein delay times of circuit devices with respect to signals, which form the X sustaining circuit and the Y sustaining circuit, are measured and the circuit devices are classified according to the delay times; sets of the classified circuit devices are selected so that the timing of the changing edge of the sustaining pulse falls within a predetermined allowance; and the sets of the selected circuit devices are installed in the plasma display apparatus.

10. A manufacturing method of a plasma display apparatus, as set forth in claim 9, wherein the plasma display panel forms a first display line between one side of the second electrode and the adjacent first electrode, a second display line between the other side of the second electrode and the adjacent first electrode, forms a display field of a frame by a plurality of subfields, and provides the gray scale by combining said subfields selectively for display; the X sustaining circuit is equipped with a first X sustaining circuit that supplies the sustaining pulse to an odd-numbered electrode of the first electrodes, and a second X sustaining circuit that supplies the sustaining pulse to an even-numbered electrode of the first electrodes; the Y sustaining circuit is equipped with a first Y sustaining circuit that supplies the sustaining pulse to an odd-numbered electrode of the second electrodes, and a second Y sustaining circuit that supplies the sustaining pulse to

an even-numbered electrode of the second electrodes; and the difference in rising or falling timing between the sustaining pulse output by the first X sustaining circuit and that output by the first or the second Y sustaining circuit, and the difference in rising or falling timing between the sustaining pulse output by the second X sustaining circuit and that output by the first or the second Y sustaining circuit are adjusted so that the differences of timings are within a predetermined range, when the circuit devices of the first and second X sustaining circuits and the first and second Y sustaining circuits are selected.

11. Control circuitry for a PDP comprising a plurality of phase adjusting circuits, each provided for a respective sustaining circuit of the PDP and each operable to adjust edge timings of sustaining pulses issued by the respective sustaining circuit.

Fig.1

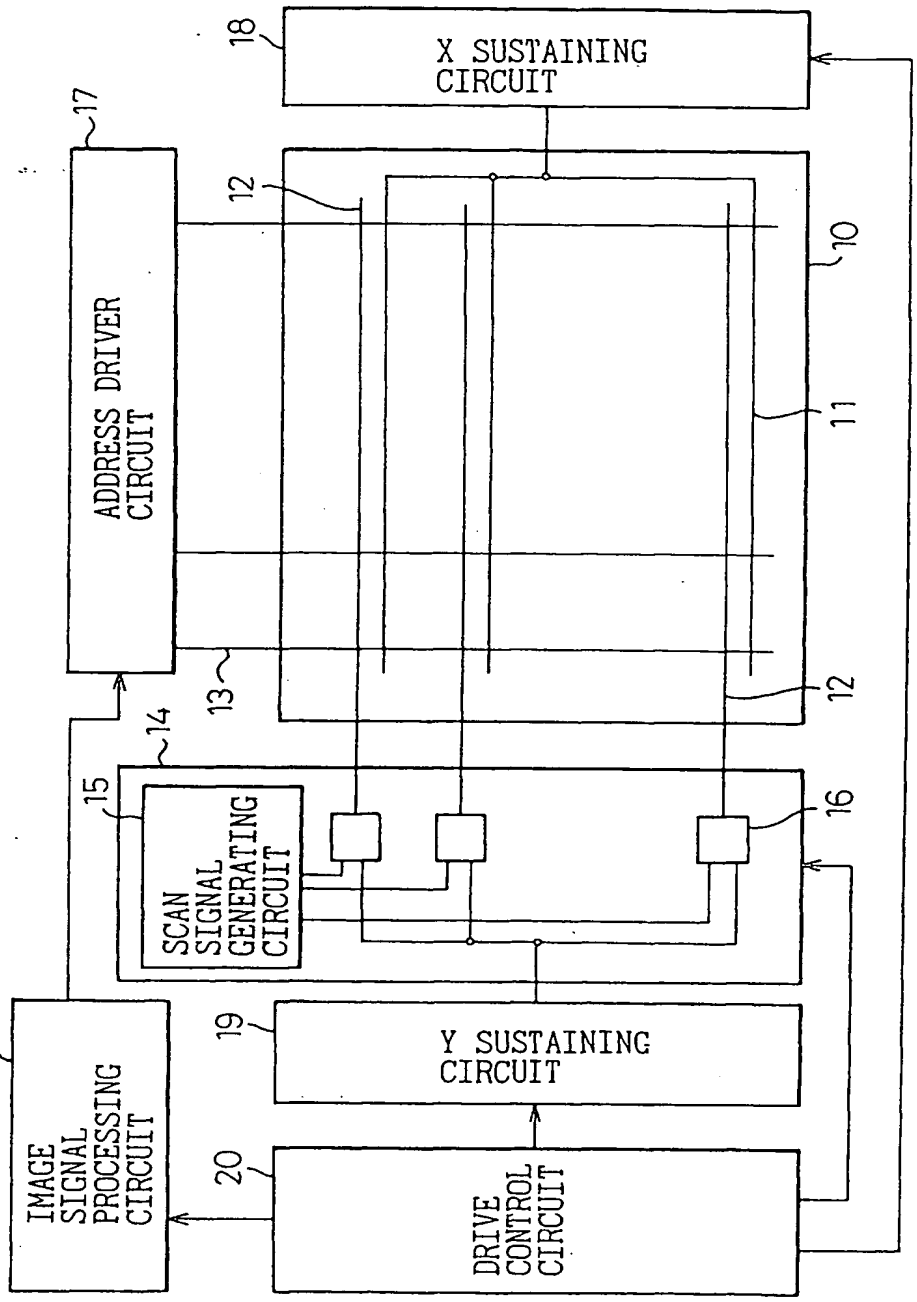

18
X SUSTAINING CIRCUIT
17
ADDRESS DRIVER CIRCUIT
12
10
11
13
12
14
15
SCAN SIGNAL GENERATING CIRCUIT
16
21
IMAGE SIGNAL PROCESSING CIRCUIT
19
Y SUSTAINING CIRCUIT
20
DRIVE CONTROL CIRCUIT

Fig.2

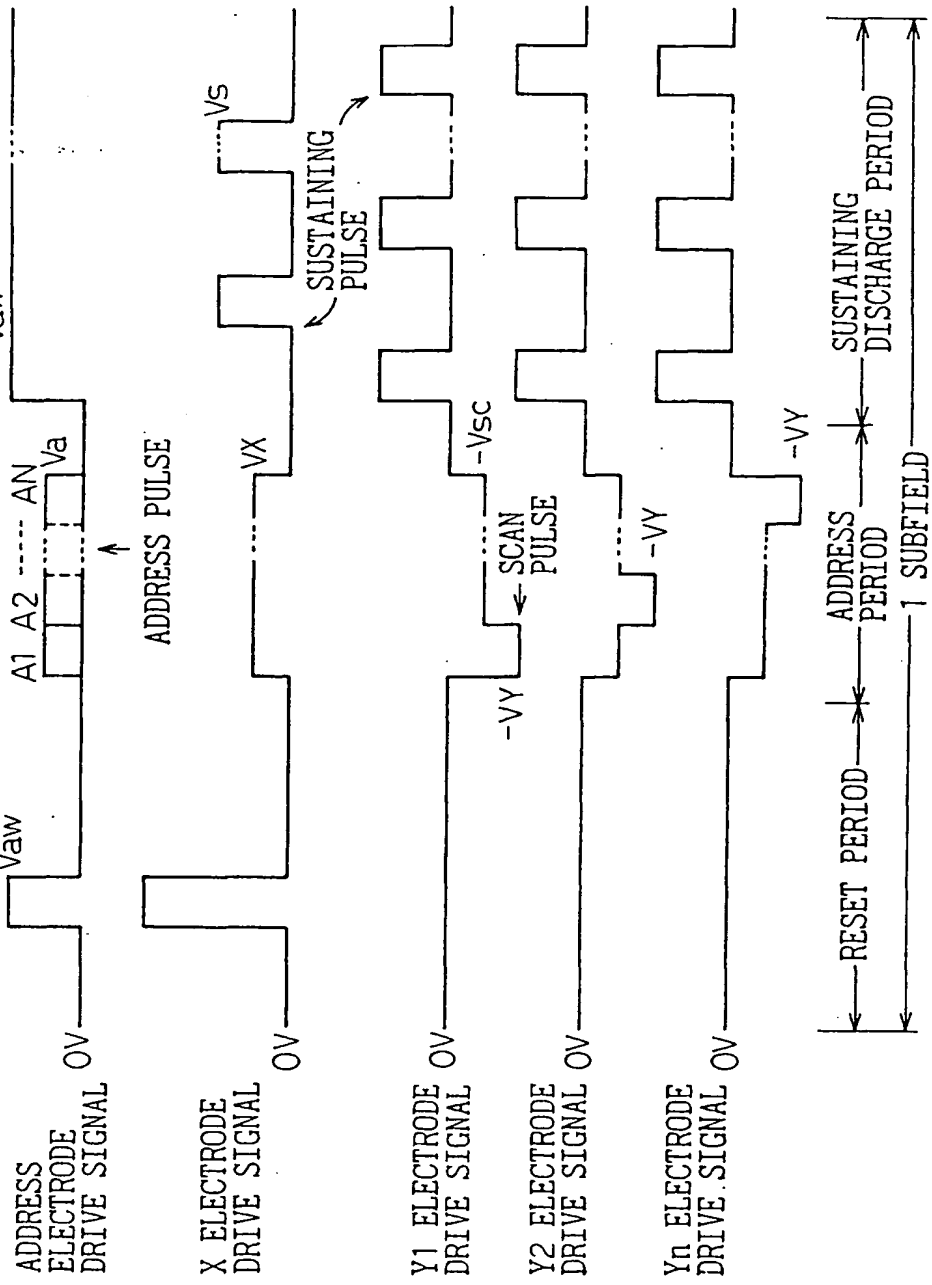

ADDRESS ELECTRODE DRIVE SIGNAL
X ELECTRODE DRIVE SIGNAL
Y1 ELECTRODE DRIVE SIGNAL
Y2 ELECTRODE DRIVE SIGNAL
Yn ELECTRODE DRIVE SIGNAL
OV
Vaw
A1
A2
AN
Va
ADDRESS PULSE
VX
Vs
SUSTAINING PULSE
-Vsc
SCAN PULSE
-VY
RESET PERIOD
ADDRESS PERIOD
SUSTAINING DISCHARGE PERIOD
1 SUBFIELD

Fig.3

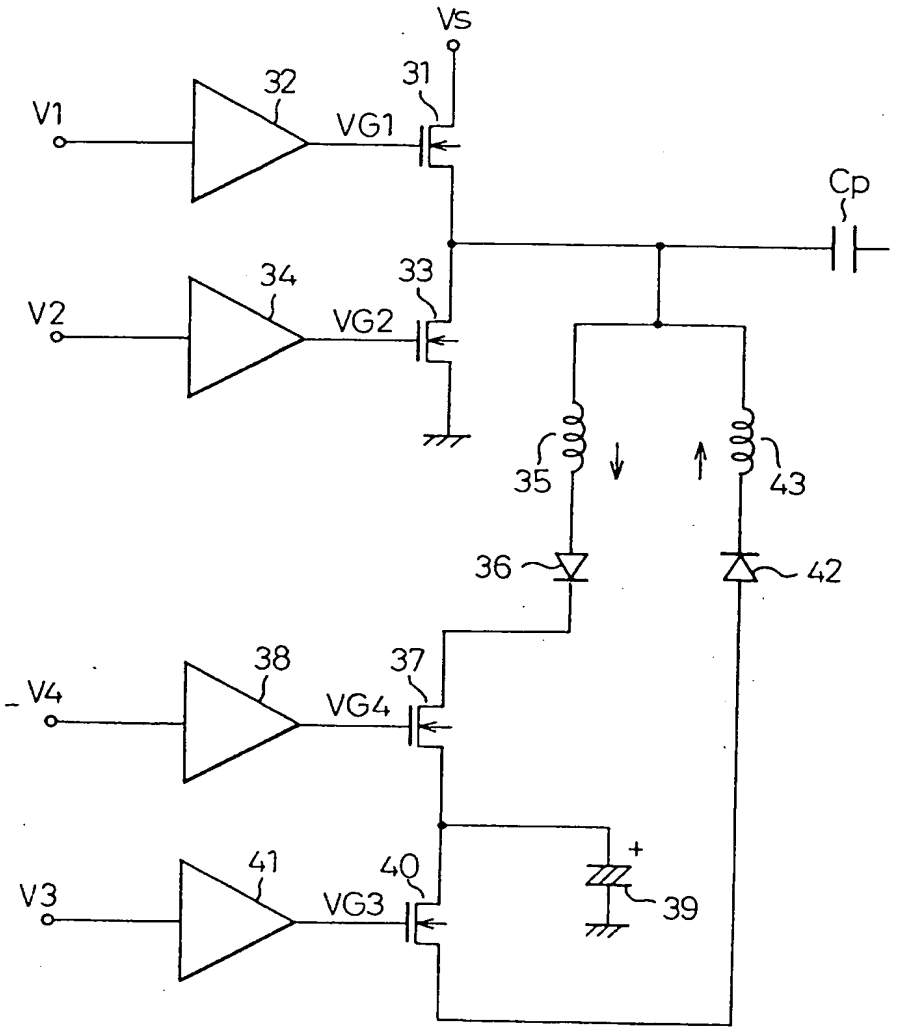

Vs
31
32
V1
VG1
Cp
33
34
V2
VG2
35
43
36
42
37
38
V4
VG4
40
41
V3
VG3
39

Fig.4

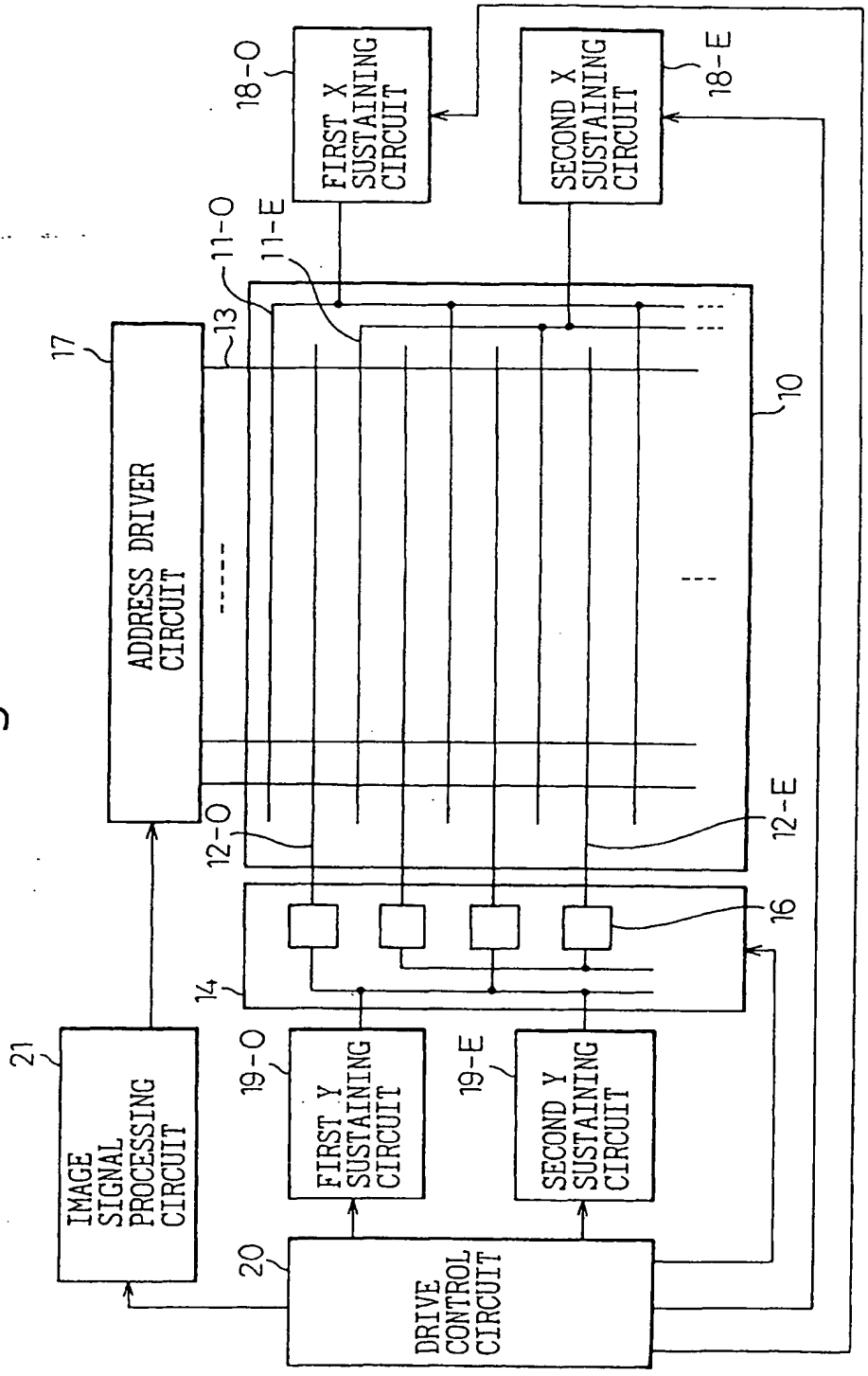

FIRST X SUSTAINING CIRCUIT
18-O
SECOND X SUSTAINING CIRCUIT
18-E
11-O
11-E
13
17
ADDRESS DRIVER CIRCUIT
10
12-O
12-E
16
14
IMAGE SIGNAL PROCESSING CIRCUIT
21
19-O
FIRST Y SUSTAINING CIRCUIT
19-E
SECOND Y SUSTAINING CIRCUIT
20
DRIVE CONTROL CIRCUIT

Fig.5A

ODD FIELD

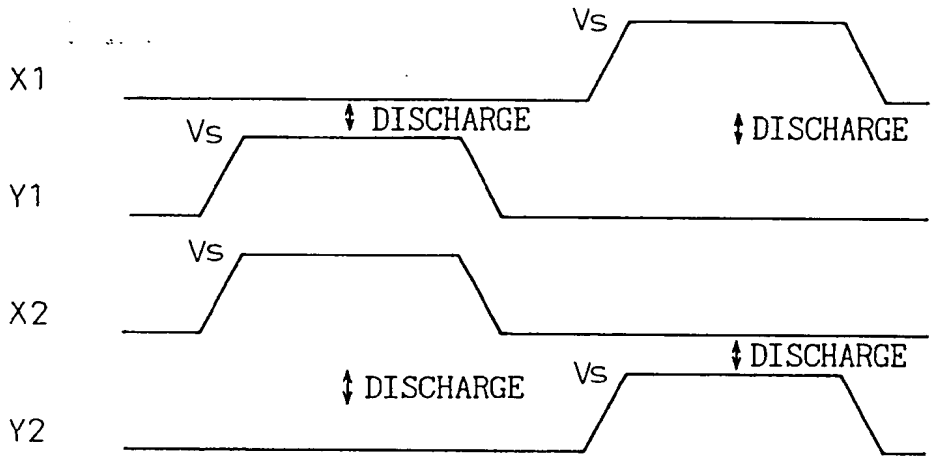


Fig.5B

EVEN FIELD

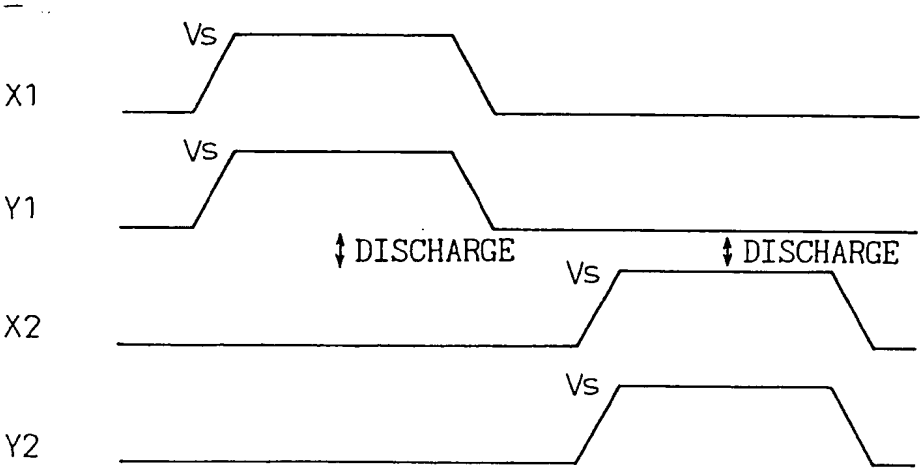


Fig.6A

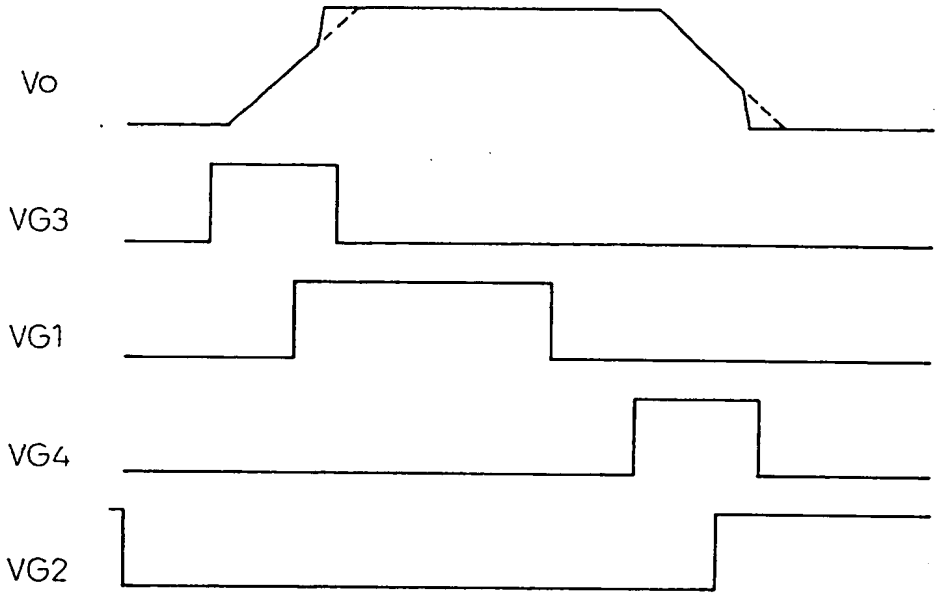


Fig.6B

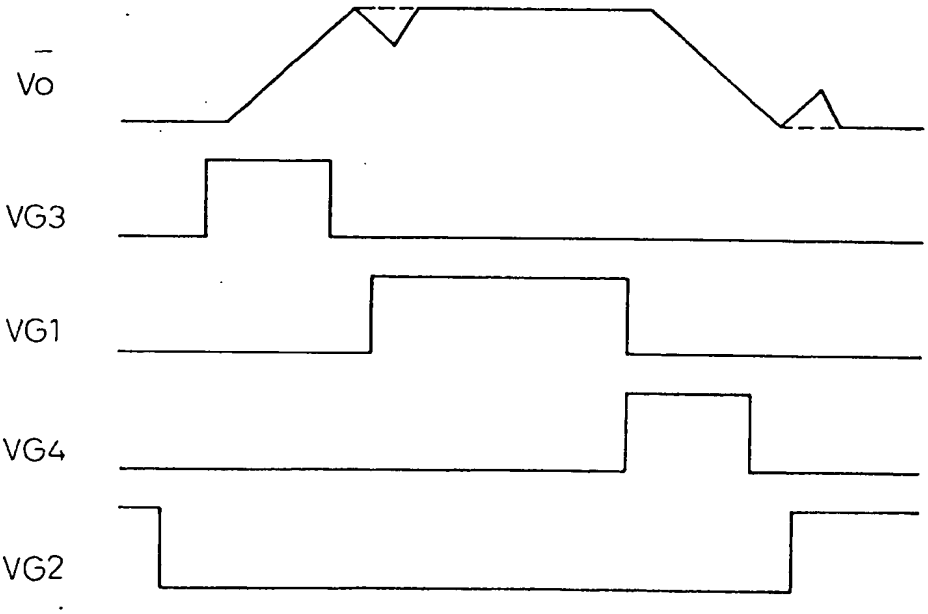


Fig.7

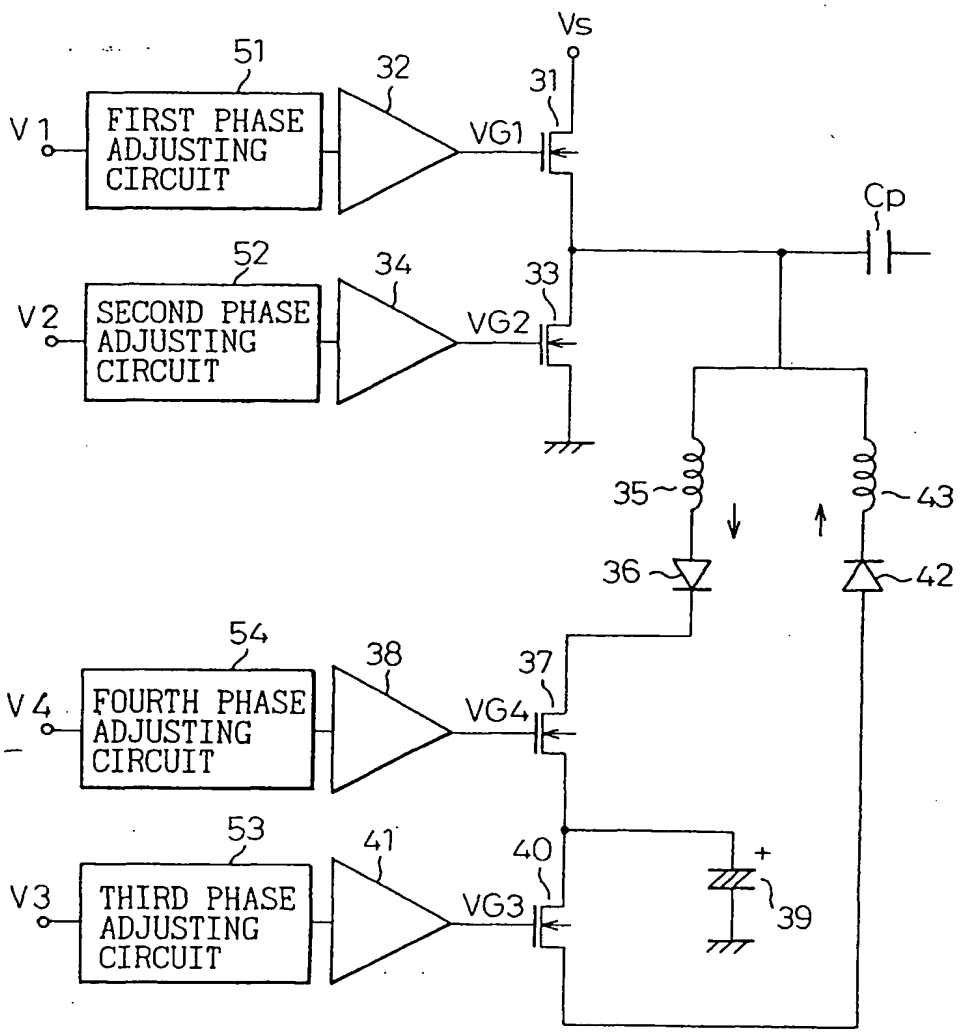

Vs
51
32
31
V1
FIRST PHASE ADJUSTING CIRCUIT
VG1
Cp
52
34
33
V2
SECOND PHASE ADJUSTING CIRCUIT
VG2
35
43
36
42
54
38
37
V4
FOURTH PHASE ADJUSTING CIRCUIT
VG4
53
41
40
V3
THIRD PHASE ADJUSTING CIRCUIT
VG3
39

Fig.8

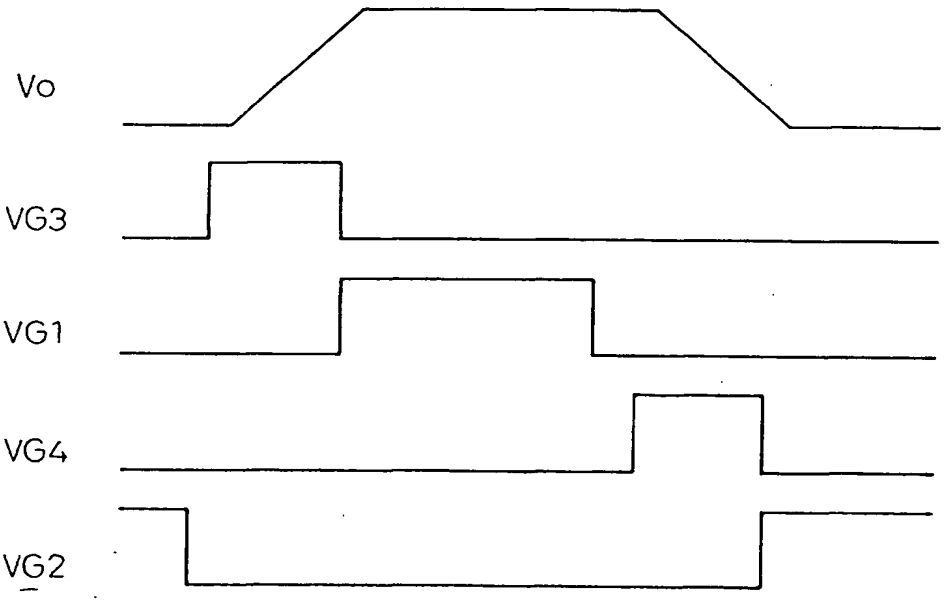


Fig.9

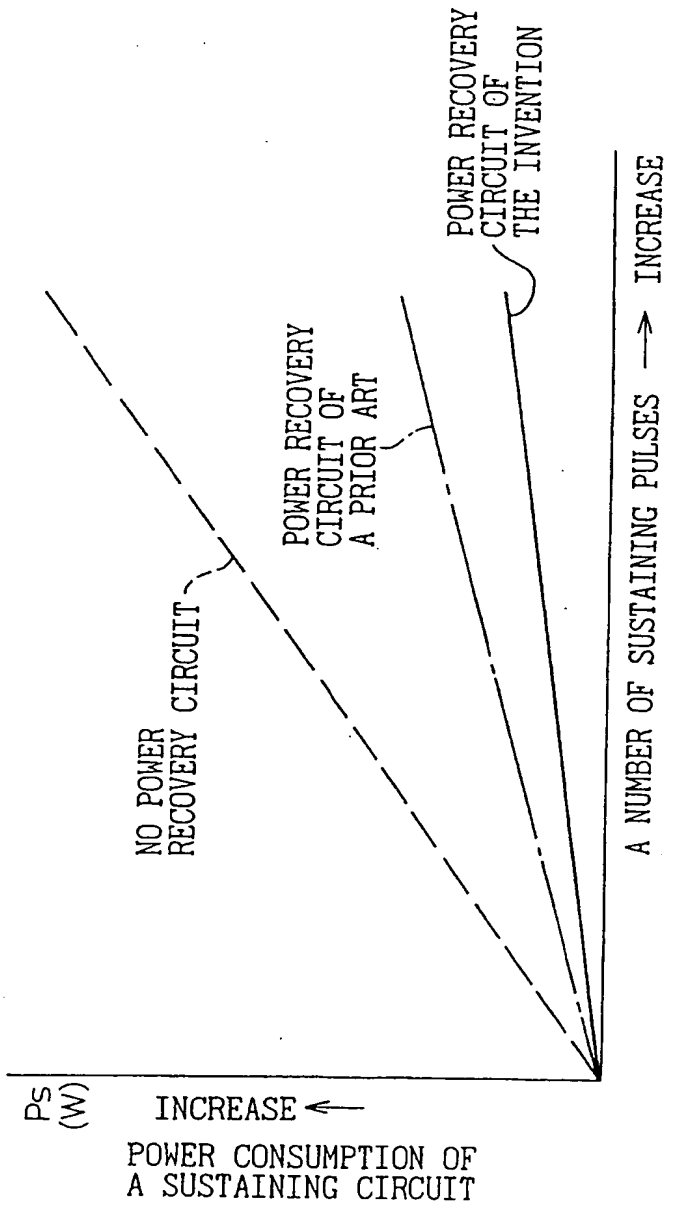

NO POWER RECOVERY CIRCUIT
POWER RECOVERY CIRCUIT OF A PRIOR ART
POWER RECOVERY CIRCUIT OF THE INVENTION
A NUMBER OF SUSTAINING PULSES → INCREASE
Ps (W)
INCREASE ←
POWER CONSUMPTION OF A SUSTAINING CIRCUIT

Fig.10

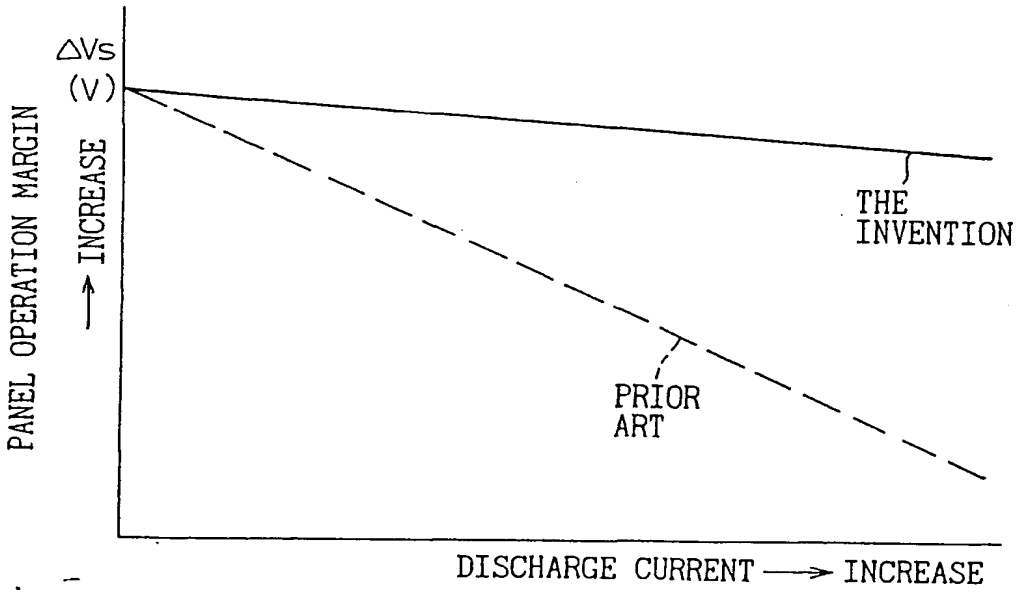

ΔVs
(V)
PANEL OPERATION MARGIN
INCREASE
THE
INVENTION
PRIOR
ART
DISCHARGE CURRENT → INCREASE

Fig.11A

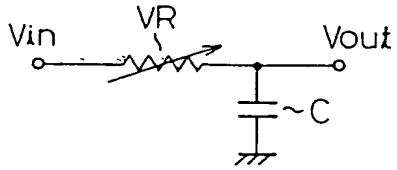


Fig.11B

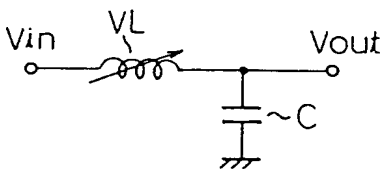


Fig.11C

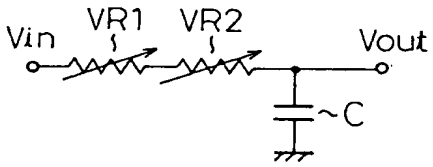


Fig.11D

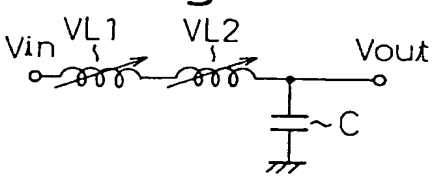


Fig.11E

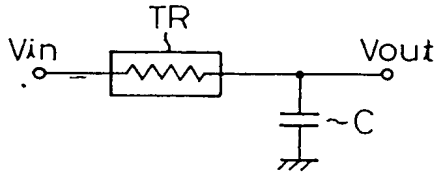


Fig.11F

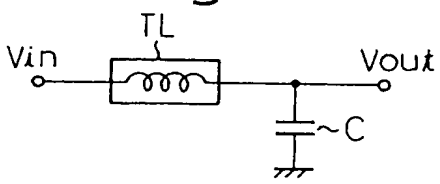


Fig.11G

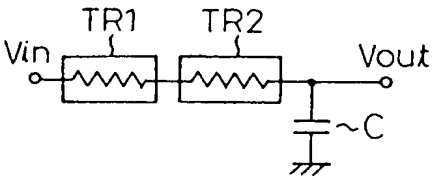


Fig.11H

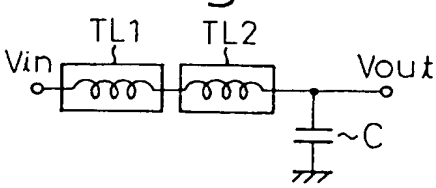


Fig.11I

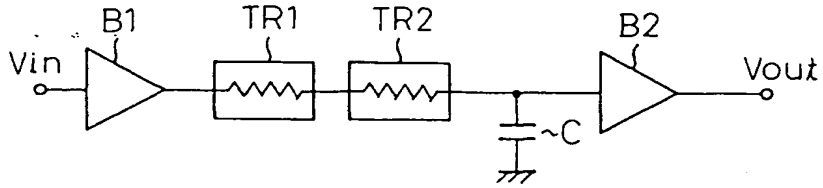


Fig.11J

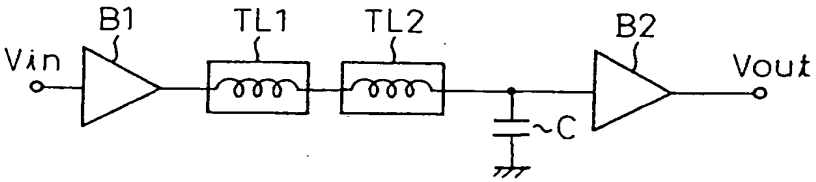


Fig.11K

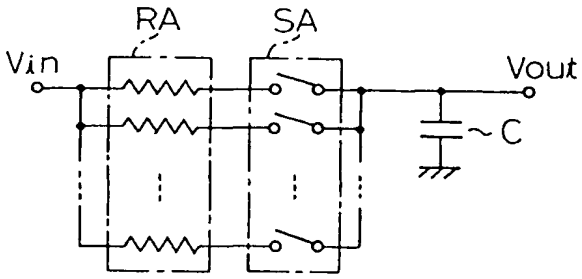


Fig.11L

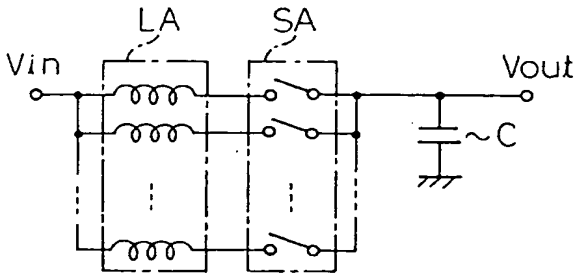


Fig.11M

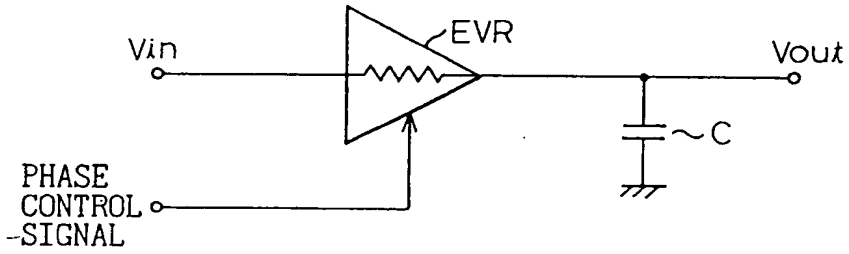


Fig.11N

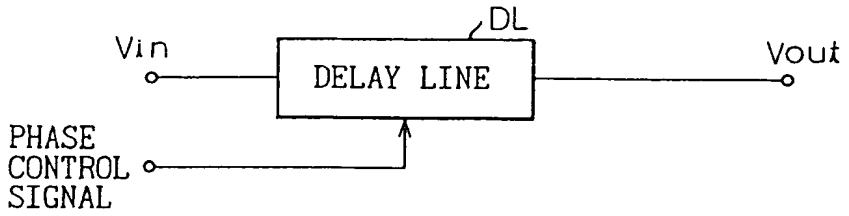


Fig.10

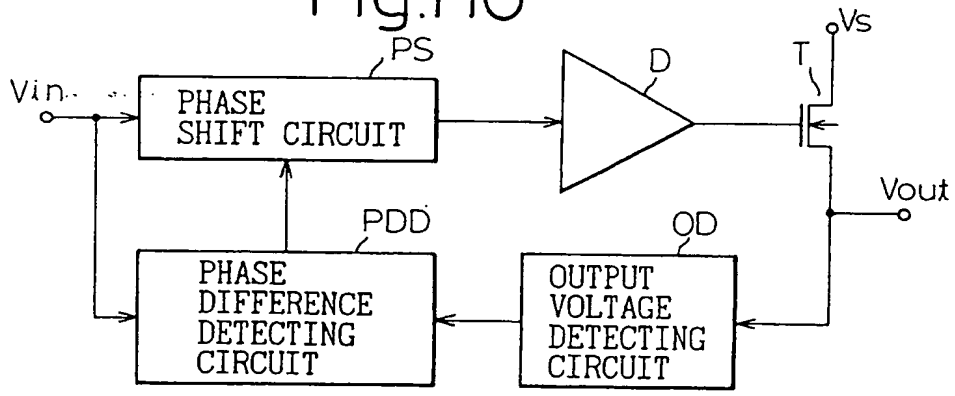


Fig.11P

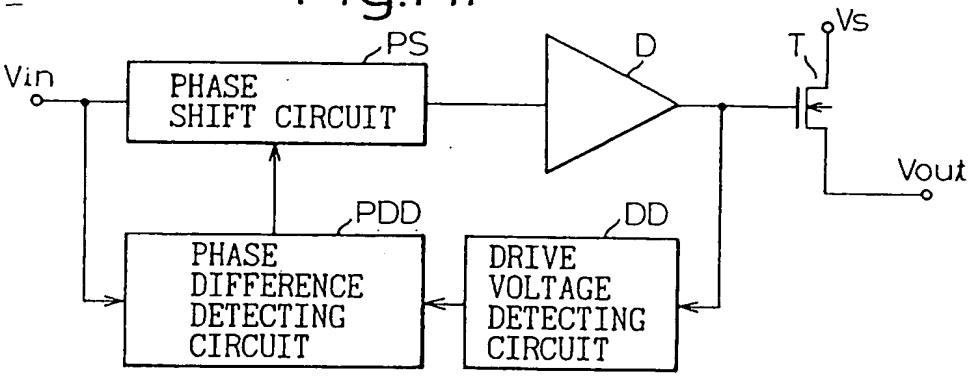


Fig.12

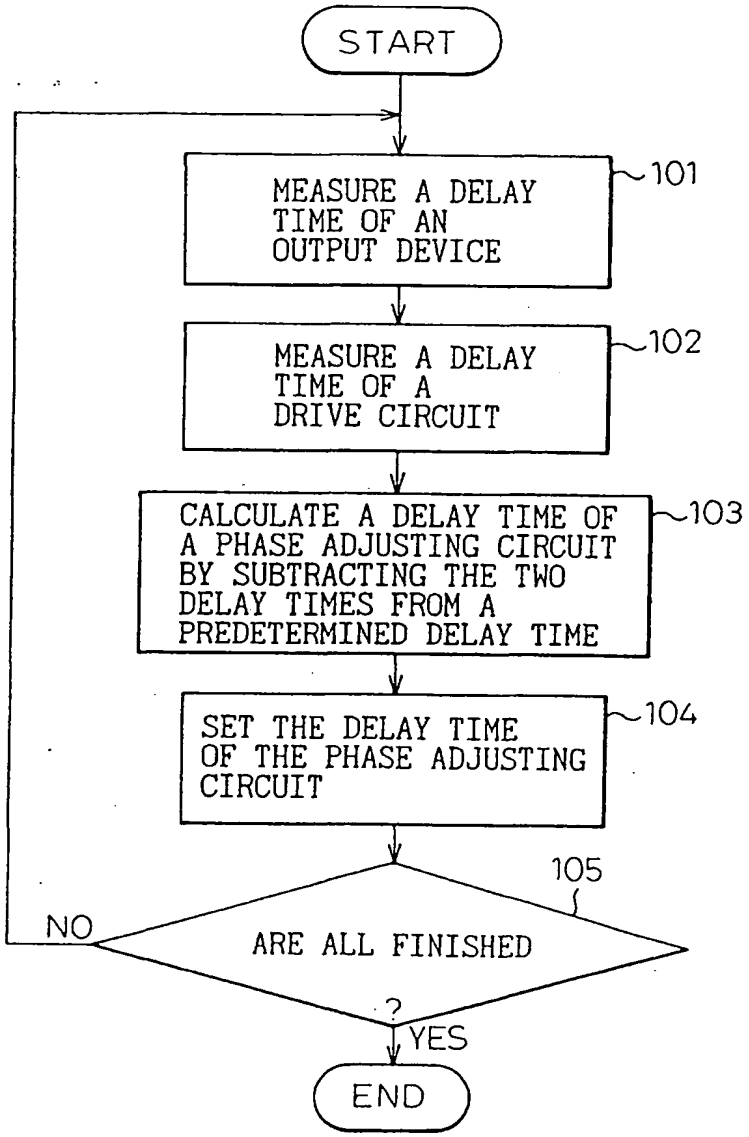

START
MEASURE A DELAY TIME OF AN OUTPUT DEVICE
101
MEASURE A DELAY TIME OF A DRIVE CIRCUIT
102
CALCULATE A DELAY TIME OF A PHASE ADJUSTING CIRCUIT BY SUBTRACTING THE TWO DELAY TIMES FROM A PREDETERMINED DELAY TIME
103
SET THE DELAY TIME OF THE PHASE ADJUSTING CIRCUIT
104
105
ARE ALL FINISHED ?
NO
YES
END

Fig.13

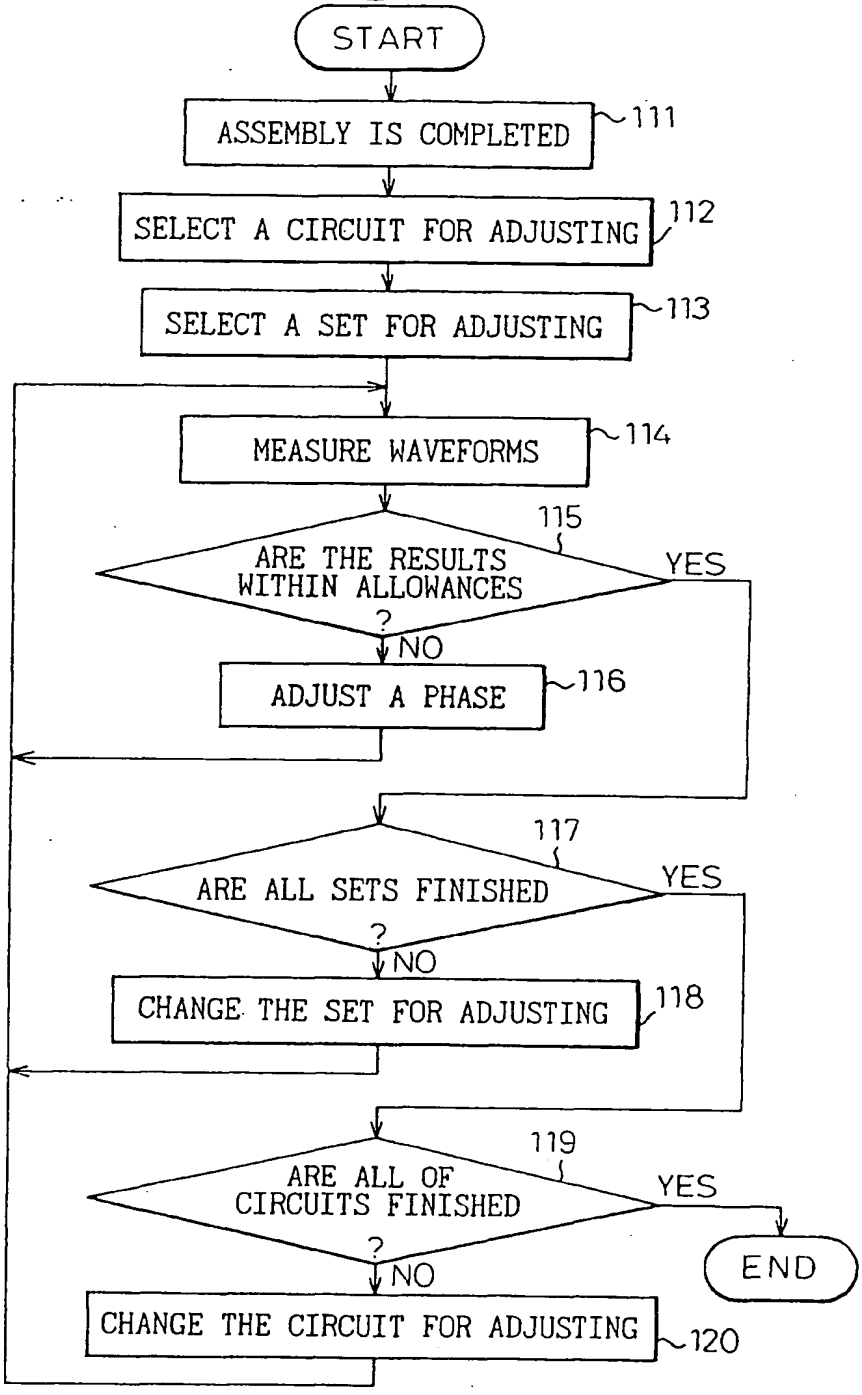

START
ASSEMBLY IS COMPLETED
111
SELECT A CIRCUIT FOR ADJUSTING
112
SELECT A SET FOR ADJUSTING
113
MEASURE WAVEFORMS
114
115
ARE THE RESULTS WITHIN ALLOWANCES ?
YES
NO
ADJUST A PHASE
116
117
ARE ALL SETS FINISHED ?
YES
NO
CHANGE THE SET FOR ADJUSTING
118
119
ARE ALL OF CIRCUITS FINISHED ?
YES
NO
END
CHANGE THE CIRCUIT FOR ADJUSTING
120

Fig.14

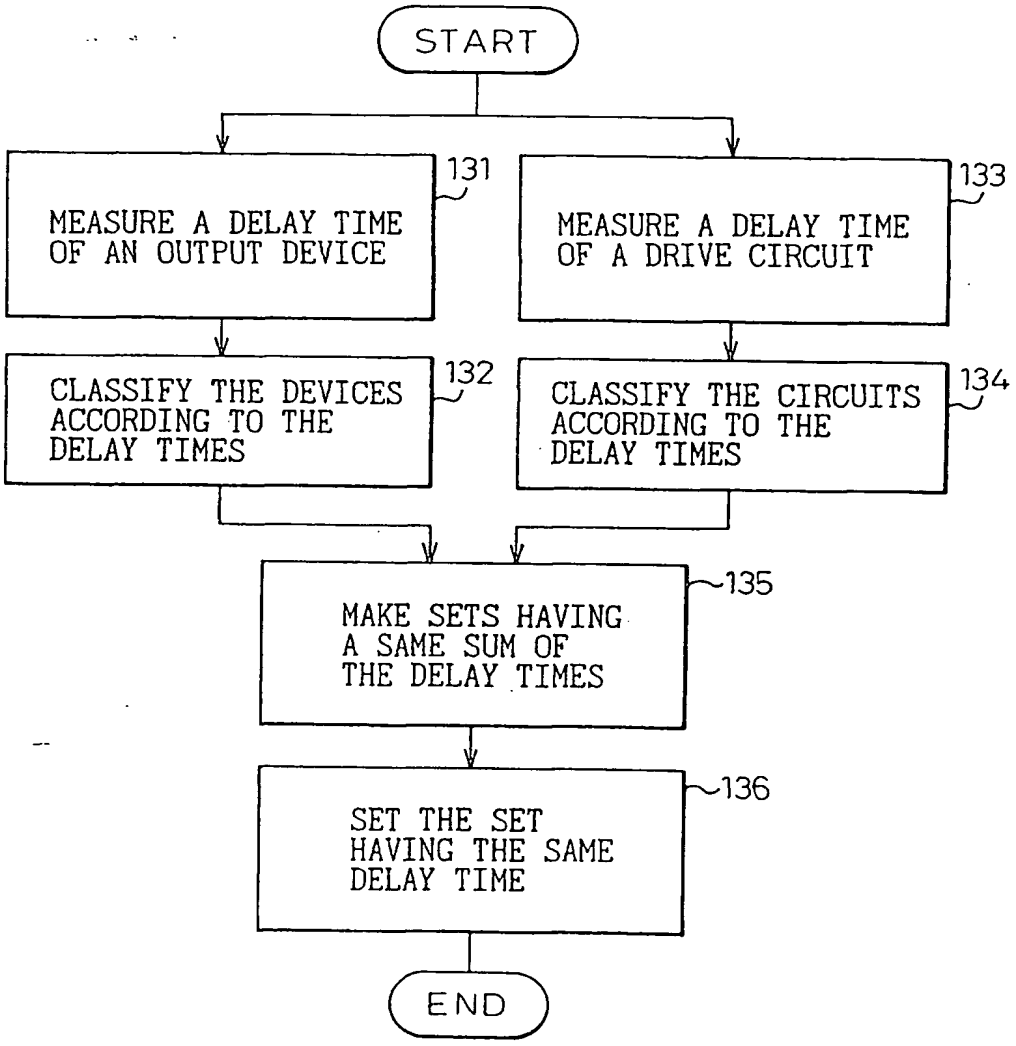

START
MEASURE A DELAY TIME OF AN OUTPUT DEVICE
131
MEASURE A DELAY TIME OF A DRIVE CIRCUIT
133
CLASSIFY THE DEVICES ACCORDING TO THE DELAY TIMES
132
CLASSIFY THE CIRCUITS ACCORDING TO THE DELAY TIMES
134
MAKE SETS HAVING A SAME SUM OF THE DELAY TIMES
135
SET THE SET HAVING THE SAME DELAY TIME
136
END

Fig.15

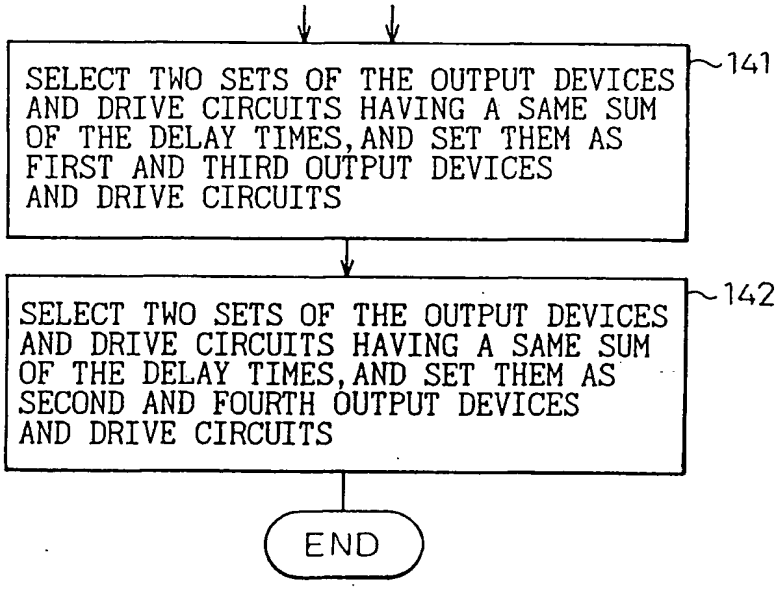
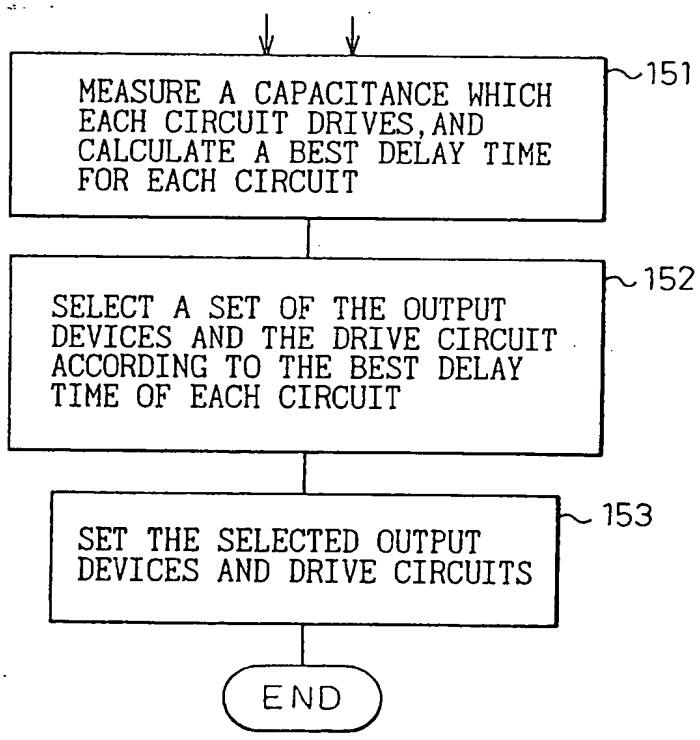

SELECT TWO SETS OF THE OUTPUT DEVICES AND DRIVE CIRCUITS HAVING A SAME SUM OF THE DELAY TIMES, AND SET THEM AS FIRST AND THIRD OUTPUT DEVICES AND DRIVE CIRCUITS
141
SELECT TWO SETS OF THE OUTPUT DEVICES AND DRIVE CIRCUITS HAVING A SAME SUM OF THE DELAY TIMES, AND SET THEM AS SECOND AND FOURTH OUTPUT DEVICES AND DRIVE CIRCUITS
142
END

Fig.16


MEASURE A CAPACITANCE WHICH EACH CIRCUIT DRIVES, AND CALCULATE A BEST DELAY TIME FOR EACH CIRCUIT
151
SELECT A SET OF THE OUTPUT DEVICES AND THE DRIVE CIRCUIT ACCORDING TO THE BEST DELAY TIME OF EACH CIRCUIT
152
SET THE SELECTED OUTPUT DEVICES AND DRIVE CIRCUITS
153
END